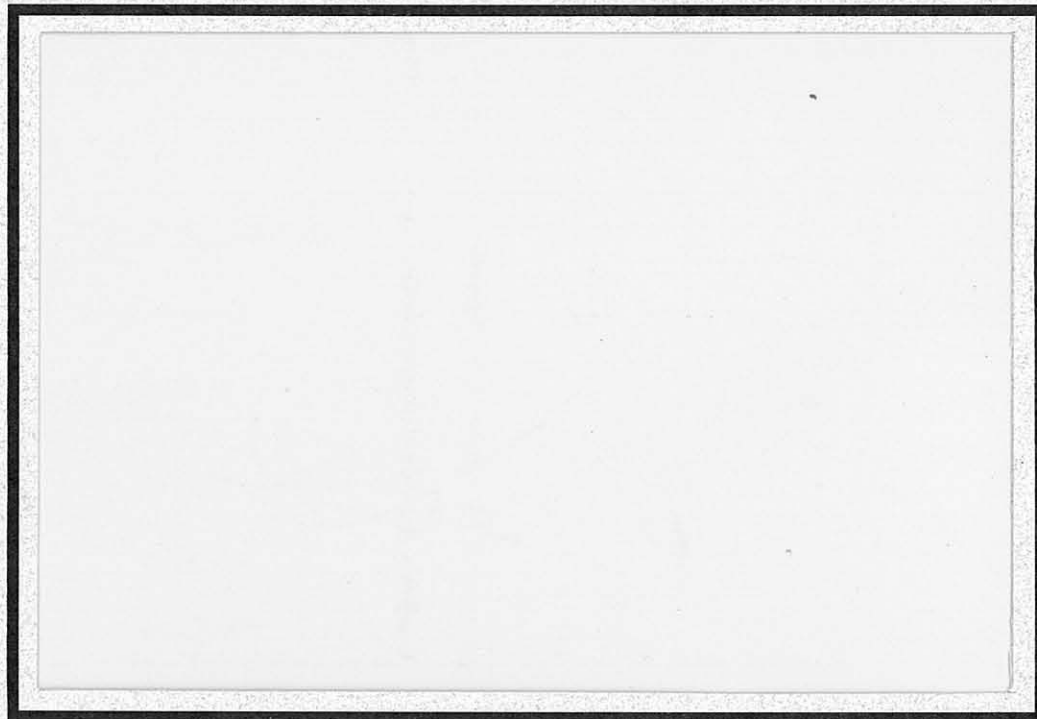


# REPORT



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**GEOLOGY AND PRODUCTION  
HISTORY OF THE BOOTJACK  
URANIUM MINE,  
NAVAJO COUNTY, ARIZONA**

by

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## **Geology and Production History of the Bootjack Uranium Mine, Navajo County, Arizona**

### **INTRODUCTION**

The Bootjack Mine was one of several large uranium deposits located by exploration drilling in the Oljeto syncline area of Monument Valley, Navajo County, Arizona. Of these ore deposits, it was the deepest (400 feet) and had one of the highest ore grades (0.46%  $U_3O_8$ ).

A map of the underground workings (Figure 1) and other data pertaining to the Bootjack Mine were recently discovered in the files of the U.S. Geological Survey (USGS) at the Denver Federal Center.<sup>1</sup> Warren I. Finch of the USGS permitted me to copy the map for the Arizona Geological Survey. Most of the information in this report is from U.S. Atomic Energy Commission (AEC) documents.

### **LOCATION AND LAND STATUS**

The Bootjack Mine was approximately 13 miles north of Kayenta, Arizona, and 3.5 miles west of U.S. Highway 163 (Figure 2). On the Boot Mesa topographic map, the mine site is labeled "Mine Shaft" and is about 1 mile northeast of the northern point of Boot Mesa (U.S. Geological Survey, 1988).

The mine was within the Navajo Indian Reservation. Mining permits and leases were issued by the Navajo Tribal Council and approved by the Bureau of Indian Affairs (BIA), U.S. Department of the Interior. Mining permits could be obtained by individual Navajos only. Permit holders could assign the mining rights to another individual or a company; like the permits, these assignments had to be approved by the Tribal Council and the BIA. Leases could be issued directly by the BIA. Permits were issued for a 2-year period and could be renewed for an additional 2 years. Leases were issued for periods up to 10 years. No more than 960 acres of tribal land could be held by any one company or individual. Both the permittee and the tribe received royalties from ore production. Based on the mine value of the ore, the tribe received between 10% and 20% royalties and the permittee between 2% and 5% royalties.

In addition to mining permits, the tribe issued drilling and exploration permits. These permits were good for 120 days and were not renewable.

### **GEOLOGIC SETTING**

The Bootjack ore deposit was one of several uranium-ore deposits that were located by "blind" drilling in the El Capitan Flat area of Monument Valley. The Flat is a large, sand-dune-covered area on the eastern side of Oljeto Wash (Figure 2). Oljeto Wash roughly follows the axis of the Oljeto syncline, which is between the Organ Rock anticline to the west and the crest of the Monument Uplift to the east. Underlying the dune sand in the Boot Mesa area is the Upper Triassic Chinle Formation. Rocks of this formation dip approximately 5° to the west into the syncline (Witkind and Thaden, 1963).



The orebodies at the Bootjack Mine were formed in a channel deposit in the basal portion of the Shinarump Member of the Chinle Formation. The channel, approximately 300 feet wide and 100 feet deep, was scoured into the underlying Moenkopi Formation of Lower Triassic age and filled with medium- to coarse-grained sandstone and conglomerate. Carbonaceous plant materials, including fossil logs, are abundant in the channel sediments. The orebodies were located along the southern flank of the channel, where it makes a sharp bend from an east-west to a north-south trend (Figure 1).

Geologic studies of the Shinarump channels in Monument Valley by Young and others (1964) indicated that the Bootjack channel was traced by industry drilling for a distance of 4.5 miles, from the western side of Boot Mesa northward to where it merges into the Big Chief, Firelight No. 6, and Alma-Seegan channels at the Sunlight South Mine. South-southwest of this confluence, but still in the Bootjack channel, was the small Big Four No. 2 deposit (3,930 tons averaging 0.26%  $U_3O_8$ ) that was mined by the Texas-Zinc Minerals Corporation in 1963.

The Bootjack deposit was unoxidized due to a perched water table in the basal Shinarump. Uraninite (uranium oxide) was the principal uranium mineral. Montrosite, a vanadium oxide, was also present, as were copper sulfides such as bornite, chalcocite, and chalcopyrite. Calcium carbonate ( $CaCO_3$ ) was the principal cementing agent of the sandstone. Data compiled by Roger C. Malan, of the AEC, for his published report on Monument Valley (Malan, 1968) indicated that the ore shipped from the Bootjack Mine averaged 0.29% copper (Cu) and 9.20%  $CaCO_3$ .

## PRODUCTION HISTORY

During 1955, numerous Navajos acquired permits to hold land for mining on the sand-covered flats along El Capitan Wash, on the eastern flank of the Oljeto syncline. They applied for these permits in anticipation of exploration drilling that was to be done by companies looking for uranium deposits farther north, near the axis of the syncline. By early 1956, more than 25 square miles on the eastern flank of the Oljeto syncline were claimed by mining permits. Because of confusion and conflicts over permits, the large area west of Oljeto Wash was withdrawn from prospecting and mining by the Navajo Tribal Council on July 19, 1955 (Navajo Tribal Council, 1955).

In November 1955, Sam Tsosie and Pat White claimed 1,000 acres on the eastern side of Boot Mesa (Figure 2) and divided them into Bootjack Nos. 1-8. On December 28, Tsosie and White were issued Navajo Tribal Mining Permit No. 384<sup>2</sup> (MP-384), which covered the 1,000 acres. In early 1956, the Gibraltar Minerals Corporation of Grand Junction, Colorado, was issued a drilling permit for the area of MP-384.

Initial drilling by Gibraltar Minerals consisted of 23 core holes with a total footage of 10,000 feet, and 60 noncore holes with a footage of 24,000 feet. This drilling located a uranium-ore deposit at an average depth of 380 feet that contained a reported 39,000 tons of ore with an average thickness of 9.5 feet and an average grade of 0.80%  $U_3O_8$ .

Having been successful in locating ore in the northern part of MP-384, Gibraltar Minerals obtained the assignment of the mining rights to 165.1 acres from Tsosie and White on May 5, 1956. The assignment was approved by the BIA on August 23.

A 437-foot, three-compartment, vertical shaft was sunk near the western end of the orebodies. The hoist for the shaft was a 6-ton, 100-horsepower, double-drum electric motor rated at 400 feet per minute (U.S. Atomic Energy Commission, 1959).

During December 1957, 1,848.77 tons of ore averaging 0.19%  $U_3O_8$  were shipped to Texas-Zinc Minerals Corporation's processing mill at Mexican Hat, Utah (Figure 2). These shipments were also analyzed for vanadium oxide ( $V_2O_5$ ), which averaged 0.21%. No data are available on the Cu or  $CaCO_3$  content.

Mining continued during 1958 at the rate of approximately 1,800 tons of ore per month with an average grade of 0.30%  $U_3O_8$  (Table 1). Most of the ore was shipped to Mexican Hat, but some shipments were made to the Kerr-McGee Oil Industries, Inc., mill at Shiprock, New Mexico, and to the mill at Tuba City, Arizona, operated by the Rare Metals Corporation of America. Approximately 7,000 tons of ore were analyzed for vanadium and found to have an average of 0.29%  $V_2O_5$ .

Modified room-and-pillar mining methods were used at the Bootjack Mine. Ore was hauled on a track system using a 2.5-ton electric trammer (U.S. Atomic Energy Commission, 1959). The mine was extremely wet; in 1959, ground water flowed into the workings at an average of 200 gallons per minute. This water was collected in the shaft sump and pumped to an evaporation pond on the surface (Figure 1). According to mine-inspection reports of 1958, the number of men employed underground averaged 30, with 8 on the surface.

During 1959, the average monthly production dropped to about 780 tons per month, but the average grade increased to 0.89%  $U_3O_8$  (Table 1) as high-grade orebodies were mined in the area where the channel bends. The mine map (Figure 1) was updated on November 10, 1959. At that time, the mine had produced about 31,400 tons, or 87% of the total tonnage mined at the Bootjack.

From October 1959 through February 1960, Gibraltar Minerals shipped approximately 250 tons per month of their high-grade ore (from 0.80% to greater than 1.00%  $U_3O_8$ ) to the Tuba City mill. The highest average monthly grade was in October 1959, when 256.80 tons of ore averaging 1.27%  $U_3O_8$  were shipped.

By early 1960, production declined as the economic ore was nearing depletion. Gibraltar Minerals made its last shipment from the Bootjack Mine in May 1960. During the 30 months that Gibraltar Minerals shipped ore from the Bootjack Mine, the company produced a total of 33,661.85 tons of ore with an average grade of 0.48%  $U_3O_8$  (Table 1).

On April 1, 1962, the AEC's allocation program (market quotas) went into effect. Under this program, the AEC would purchase uranium concentrate (yellow cake) only from ore discovered before November 24, 1958, or equal to the amount of ore produced from July 1, 1956, through June 30, 1960 (Albrethsen and McGinley, 1982). The latter method was used to help small miners who did not block out large amounts of ore prior to mining.

On May 4, 1962, Ivor Adair of the A and B Mining Company, Moab, Utah, mentioned to me that he hoped to get an assignment of the Bootjack mining permit and an AEC allocation so he could rework the old mine dump left by Gibraltar. Records of the Navajo Tribal Mining Department, however, indicate that no assignment was ever issued.

In 1965, Pat White applied to the Navajo Tribal Council to renew MP-384. Because Tsosie did not want to continue their partnership, White dissolved it on April 27, 1965, and on April 28, White was issued MP-607, which covered the same 1,000 acres as MP-384.

As controller of MP-607, White applied to the AEC for an allocation so that some cleanup mining could be done at the Bootjack Mine. In June 1965, White received an

allocation (A-747) to produce not more than 107,094 pounds of  $U_3O_8$  in ore per year. This allocation was based on past production, when Gibraltar Minerals operated the mine.

On June 26, the BIA approved the assignment of the rights of the 165.1 acres held by Gibraltar Minerals to A-Z Minerals. A-Z Minerals was a subsidiary of the Atlas Corporation, which was formed when Atlas acquired the Texas-Zinc Minerals Corporation on July 31, 1963 (Albrethsen and McGinley, 1982).

A-Z Minerals reopened the Bootjack Mine in July 1965 and in August began shipping ore to the Atlas mill at Moab, Utah. At that time, 500 gallons of water per minute were being pumped from the mine. During 1965, the Bootjack Mine produced 1,436.52 tons of ore containing 4,166.38 pounds  $U_3O_8$  and averaging 0.15%  $U_3O_8$  (Table 1). Mine-inspection reports for 1965 show that six men (on average) were employed underground and six on the surface during the year. Although A-Z Minerals exceeded the Bootjack's allocation, the excess pounds were used to fill other allocations held by Atlas. Final shipments were made from the Bootjack in February 1966, at which time the mine was closed for good. The headframe and all surface buildings have since been removed, and the shaft has been capped.

During the life of the mine, the Bootjack produced a total of 36,236.40 tons of ore with an average grade of 0.46%  $U_3O_8$ . This number is slightly lower than the 36,662 tons of ore reported by Scarborough (1981, p. 218). The Bootjack was the deepest uranium-ore deposit to be mined in the Monument Valley area. With the exception of the Fern Mine (9,582.43 tons with a grade of 0.66%  $U_3O_8$ ), it had the richest grade of all mines in the Oljeto syncline.

All of the uranium concentrate produced from the Bootjack ore was sold to the AEC. Copper recovered at the Mexican Hat and Moab mills was sold to a smelter in Arizona. Vanadium recovered at Shiprock was also purchased by the AEC. The Tuba City mill paid for some vanadium but did not recover it.

#### ACKNOWLEDGMENT

Reviews of this manuscript by Jon E. Spencer and Emily C. Creigh of the Arizona Geological Survey greatly improved it.

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<sup>1</sup> This information is part of the collection of geological data that was moved to the Denver Federal Center by the Department of Energy (DOE). In 1983, the uranium resource and liaison programs of the DOE were transferred from Grand Junction, Colorado, to Washington, D.C. During the next few years, all of the geologic data and publications that the AEC, Energy Research and Development Administration, and DOE had collected and produced from 1947 to 1983 were relocated to the USGS in Denver.

<sup>2</sup> Legal Description of Navajo Tribal Mining Permit No. 384:

"Commencing at corner no. 1, which bears N63°36'E, 15,990 feet to U.S. Mineral Monument No. 4, thence S53°41'W, 5,150 feet to corner no. 2, thence N29°52'W, 8,458 feet to corner no. 3, thence N53°41'E, 5,150 feet to corner no. 4, thence S29°52'E, 8,458 feet to corner no. 1, the point of beginning, contains 1,000 acres."

--From the files of the Navajo Tribal Mining Department, Window Rock, Arizona

Table 1. Ore production of the Bootjack Mine, Navajo County, Arizona.

YEAR	SHIPPER	TONS OF ORE	POUNDS U <sub>3</sub> O <sub>8</sub>	% U <sub>3</sub> O <sub>8</sub>	DELIVERY POINT
1957	Gibraltar Minerals	1,848.77	6,864.25	0.19	Mexican Hat
1958	Gibraltar Minerals	21,252.35	129,310.46	0.30	Mexican Hat, Tuba City, Shiprock
1959	Gibraltar Minerals	9,106.90	162,179.46	0.89	Mexican Hat, Tuba City
1960	Gibraltar Minerals	1,453.83	22,927.85	0.79	Mexican Hat, Tuba City
1965	A-Z Minerals	1,436.52	4,166.38	0.15	Moab
1966	A-Z Minerals	<u>1,138.03</u>	<u>5,561.75</u>	<u>0.24</u>	Moab
Total		36,236.40	331,010.15	0.46	

Source: Unpublished ore-production records, U.S. Atomic Energy Commission, Grand Junction, Colorado, office.



Figure 1. Plan map of the underground workings of the Bootjack uranium mine, Navajo County, Arizona.

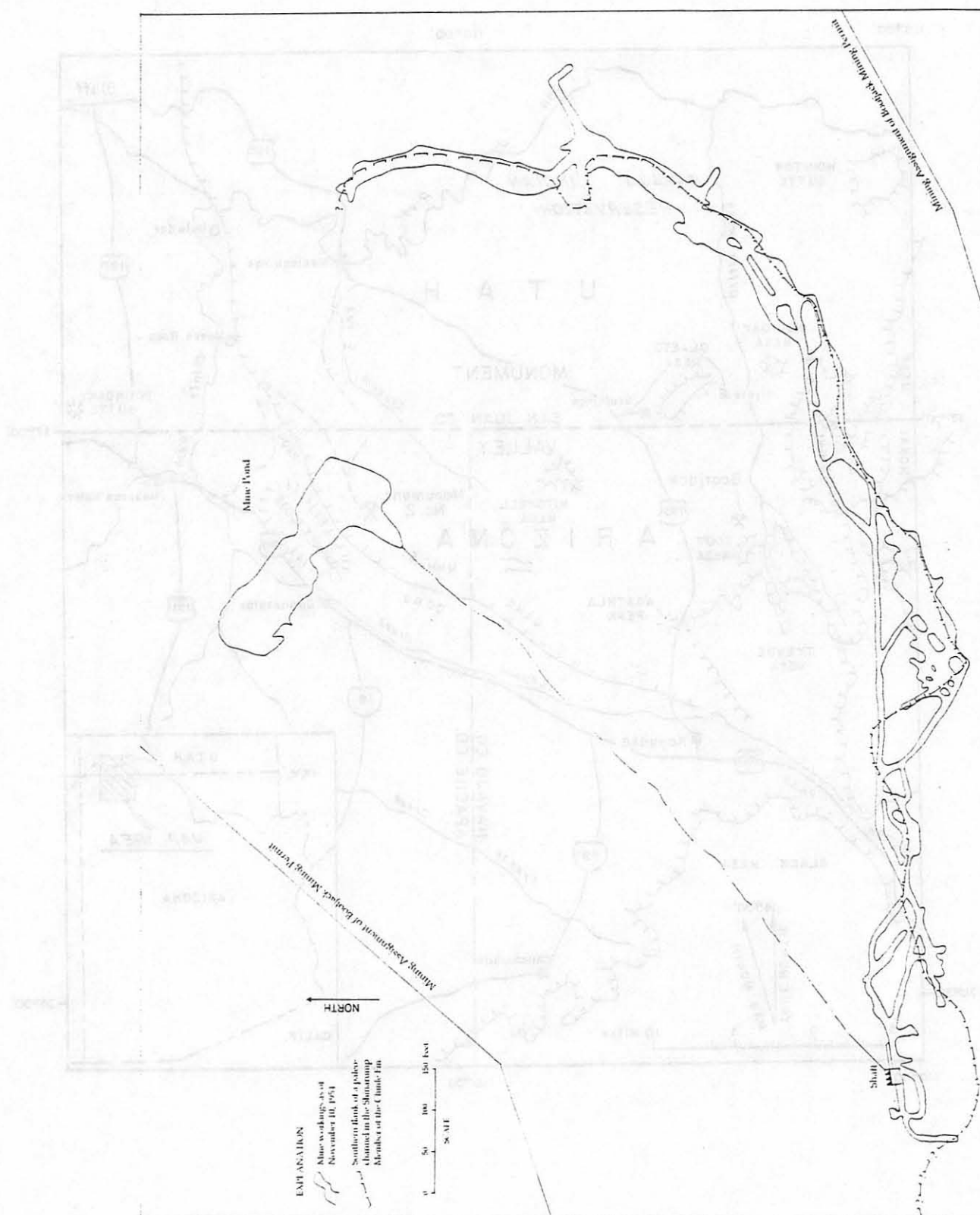


Figure 2. Index map of Monument Valley Arizona-Utah, showing the location of the Bootjack uranium mine.

